Runoff and Soil Losses from Barnes Soils In the Northwestern Corn Belt

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Runoff and Soil Losses from Barnes Soils In the Northwestern Corn Belt[1]

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Introduction

Barnes soils, although located on the northwestern fringe of the Corn Belt, are farmed as intensively as those in the central part of the Corn Belt. Frost-free growing season is short (136 days). On these lighter soils, water conservation measures are necessary. However, the need for water erosion control practices had not been established before the initiation of runoff and soil losses study.

Erosion study plots were established in 1960 on a small farm near Morris, Minn., later named the Barnes-Aastad Soil and Water Conservation Research Association Farm. The first measurements of the 10-year study on runoff and soil losses were made in 1961.

The Minnesota location has a continental climate characterized by wide variations in temperature, low winter precipitation, and ample summer rainfall (*6*).[3] Average maximum temperatures are 90° to 100° F and average minimum temperatures are −30° to −35°. Average annual precipitation at Morris is about 24 inches; about 18 inches is rainfall and the rest is snowmelt. Thunderstorms occur on an average of 30 days a year.

Several previous reports have been made on the results of the project. The first five years results on runoff and erosion were summarized by Burwell and Holt (*1*). Timmons and associates (*5*) analyzed crop nutrient losses associated with the runoff and erosion for 1966 and 1967. Holt (*3*) also reported on nutrient losses from the cropping treatments on the erosion plots. Burwell and others (*2*) discussed nutrient transport in surface runoff as influenced by soil, cover, and seasonal periods for 1962-71. This publication summarizes and analyzes the entire 10-year study of runoff and soil loss.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 8.

Study Procedures

This section describes the soils; cropping treatments, plot arrangement, and dimensions; equipment and procedures for measuring rainfall variables, runoff and soil loss.

Topography and Soils.—The problem area surrounding the experimental site, including west central and southwestern Minnesota, northwestern Iowa and eastern South Dakota, is characterized by complex topography and soil features which makes the application of soil conservation practices complicated and difficult on many farms. The effects of glaciation are seen in steep but short slopes and irregular slope segments.

The plot area was chosen primarily for soil and slope. Barnes loam is a major soil type in the area and has an average 6 percent slope. Because soil losses are low and difficult to measure on land with low slope steepness, finding land near higher steepness used for farming was desirable. The area selected is located about 8 miles northeast of Morris, Minn. (See appendix A for a detailed soil description.)

Treatments and Plots.—Three cropping treatments requiring five plots were evaluated. To determine the influence of climate on local erosion, a good soil-saving rotation of corn, oats, and alfalfa-brome hay and an erosive crop, continuous corn, were used. Both of these systems had previously been evaluated in other parts of the country. Therefore, the expected results would confirm the validity of such cropping factors for the geographical locale that are given in Agriculture Handbook 282 (7). A third treatment, cultivated fallow, was included to determine the erodibility of Barnes loam soil. Whereas soil preparation and cultivation for corn and oats varies somewhat for different parts of the country, the cultivated fallow soil preparation has been used throughout as a standard bare soil treatment for erosion plots under rainfall and under simulated rainfall. Details on tillage and soil management are given in appendix B.

Erosion plots were standardized at 13⅓ feet wide (four 40-inch corn rows) and 72½ feet long. Border strips, 6⅔ feet wide, maintained the same as the plot, were provided on each side of the plots. All tillage and row direction was up-and-down slope. Three replications of the treatments were located about 150 feet apart.

Equipment and Measurements.—A weather station was located near the erosion plots. Rainfall was measured with a recording gage and a standard gage. Other data taken but not reported with this project were daily maximum and minimum temperatures, evaporation, and wind movement.

Standard runoff and soil loss measuring equipment was used. With some variation, the equipment was the same as described by Mutchler (*4*). Multi-slot divisors separated the runoff after a sludge tank and after the first of two aliquot tanks. After each storm, soil and water losses in the sludge tank and aliquot tanks (if enough runoff had occurred) were manually stirred and dip samples taken for sediment concentration analysis.

One replication was protected from freezing using insulation and automatic electric heaters to allow sampling runoff in freezing weather and during spring thaw. Measuring equipment on the other two replicates was disconnected during the winter.

Results and Discussion

The 10-year average annual precipitation, runoff, and soil loss by crop stage periods for the soil-cover treatments listed are shown in table 1. Table 2 shows the annual soil loss caused by rainfall runoff.

Detailed data tables are included in appendix C showing crop stage period total values of rainfall where runoff occurred, and runoff and soil loss as averages of plot replicates for the treatments.

Crop Stage Periods.—The widely-changing cover given land by crop vegetation throughout the year prompted the separation of runoff and soil loss into cropping stage periods (table 3). The periods used here generally follow those defined and used in Agriculture Handbook 282 (*7*) to establish cropping factors (C-values) used in the Universal Soil Loss Equation.

Land used for rotation corn and that used for continuous corn was fall plowed an average of 9 days after corn harvest. Plowing in the fall is a common practice on such soils as Barnes. Reasons for this in preference to spring plowing are time (short growing season), moisture conditions (wet conditions in the spring), and better tilth (freezing overwinter helps make a better seedbed for corn and grain). The primary objective of the experiment was to establish soil loss values under generally-prevailing practices that had also been used in other parts of the country. Investigation of minimum tillage was not an objective.

Results for the fallow treatment were divided into periods identical to crop stage periods used for corn to allow comparisons of data. Those periods for hay were established similar to corn for the same purpose.

Crop stages for oats during the crop season were the same length as for corn except period 3. However, except for annual values, the different planting date for corn precludes comparison of runoff and soil loss from oats with that from corn and hay.

Period 6 was used to separate soil and water losses because of snowmelt. A period had been estimated; however, all snowmelt losses occurred during the period represented by crop stage 5.

TABLE 1.—*10-year average annual precipitation, runoff, and soil loss by crop stage periods*

	Spring						Fall		Annual average	
	5	6	1	2	3	4	5	6	Rain	Snowmelt
				Precipitation – *Inches*						
Corn and fallow	3.47	[1]3.36	3.75	3.53	7.01	0.40	1.84	1.29	20.00	4.65
				Runoff – *Inches*						
Fallow (no crop)	.30	3.31	.26	.57	.40	0	.07	0	1.69	3.31
Continuous corn	.21	2.06	.30	.47	.33	0	.01	0	1.32	2.06
Rotation corn	.04	.97	.25	.37	.23	0	.01	0	.90	.97
				Soil loss – *Tons per acre*						
Fallow (no crop)	2.58	1.12	3.40	6.41	2.90	.01	.07	0	15.37	1.12
Continuous corn	.99	.25	2.50	3.08	.52	0	.01	0	7.10	.25
Rotation corn	.07	0	1.51	1.51	.26	0	.02	0	3.37	0
		Spring					Fall			
		4A	6	4B	4C	4D	4A	6		
				Precipitation – *Inches*						
Hay		3.47	[1]3.36	3.75	3.53	7.41	1.84	1.29	20.00	4.65
				Runoff – *Inches*						
		.01	5.00	.05	.08	.02	.01	0	.17	5.00
				Soil loss – *Tons per acre*						
		0	0	0	0	0	.01	0	.01	0
	Spring						Fall			
	1	6	1	2	3	4	4A	6		
				Precipitation – *Inches*						
Oats	1.35	[1]3.36	3.42	4.19	2.32	6.48	2.25	1.29	20.01	4.65
				Runoff – *Inches*						
	.27	2.22	.18	.34	.08	.04	.05	0	.96	2.22
				Soil loss – *Tons per acre*						
	[2]1.25	.14	.41	.13	.01	0	0	0	1.80	.14

[1] Snowfall estimated from Morris, Minn., records.
[2] See footnote 1, table 14, appendix C.

Precipitation.—Rainfall was measured at the site of the plots. Snow records from the West Central Agricultural Experiment Station at Morris were used to estimate snowfall. Precipitation for the various cropping periods is given in tables 4 and 5 of the appendix. Average annual precipitation amounts for the crop periods are given in table 1.

To compare rainfall amounts measured during the crop stage periods, rainfall rate was expressed as amount per year. These rates, on an average annual basis, indicate that rainfall was about 4 to 8 inches during the first 60 days after corn is planted (fig. 1). During

TABLE 2.—*Soil losses caused by rainfall*

Year	Treatment				
			Rotation		
	Fallow	Continuous corn	Corn	Oats	Hay
	Tons per acre				
1962	80.36	44.49	21.05	16.44	0
1963	.77	.70	.41	.03	0
1964	34.90	10.51	3.64	.13	0
1965	7.17	2.43	1.07	.24	0
1966	3.52	.36	.19	0	0
1967	9.54	3.14	.62	.64	0
1968	1.27	.55	.34	.06	0
1969	2.41	.29	.26	.05	0
1970	5.56	5.72	4.21	.32	0
1971	8.11	2.79	1.83	.07	.10
Average	15.36	7.10	3.36	1.80	.01

dry years, however, rainfall rates are below 20 inches per year. The high extreme rates for crop stages 5, 1, and 2 illustrate the opportunity for rainfall excess and runoff. From mid-July through October, when temperatures were high and corn was maturing, rainfall rates were consistently low.

TABLE 3.—*Dates of cropping periods for treatments*

Number	Cropping period description	Beginning dates
	Corn and cultivated fallow:	
1	Corn planting to 1-month after planting	May 16
2	From 1-month to 2-months after planting	June 16
3	From 2-months after planting to harvesting	July 16
4	Corn harvest to plowing	Oct. 12
5	Rough plow (Fall and Spring)	Oct. 21
	Rotation hay:	
4A Spring	January 1 to corn planting date	Jan. 1
4B	Corn 1 equivalent	May 16
4C	Corn 2 equivalent	June 16
4D	Corn 3 plus corn 4 equivalent	July 16
5 Fall	Rough plow to December 31	Oct. 21
	Rotation oats:	
5 Spring	January 1 to seeding	Jan. 1
1	Seeding to 1-month after seeding	Apr. 29
2	From 1-month to 2-months after seeding	May 29
3	From 2-months after seeding to oat harvest	June 29
4	Oat harvest to corn harvest time	July 27
4A Fall	Corn harvest to December 31	Oct. 12
6	Snowmelt (all treatments)	Dec. 15 to Apr. 1

Erosion potential is represented by the erosion index, EI, as illustrated by the curve in figure 2. The erosion plots were located close to the division of areas for curves 1 and 12 in Agriculture Handbook No. 282. Smoothed data for the 10-year average EI are in excellent agreement with the published curves. The curves reflect the greater incidence of high intensity storms during July and August. About 80 percent of the erosion potential occurs in June, July, and August.

Average measured EI values for the 10 years was 103 compared with the value of 100 from Agricultural Handbook No. 282, which is representative of erosion potential from long-term rainfall records over the general Dakota-Minnesota area.

Runoff.—The major source of runoff was from snowmelt (table 1). Because the ground was frozen, almost all the snowmelt ran off. Unfortunately, the snowdrifts that formed on the plots were influenced more by topographic features than by cover. No comparison of snowmelt runoff from the different treatments can be made.

Runoff amounts generally followed the rainfall values as would be expected. Runoff as percent of rainfall was highest in the spring and around early July. Springs were usually wet because of snowmelt

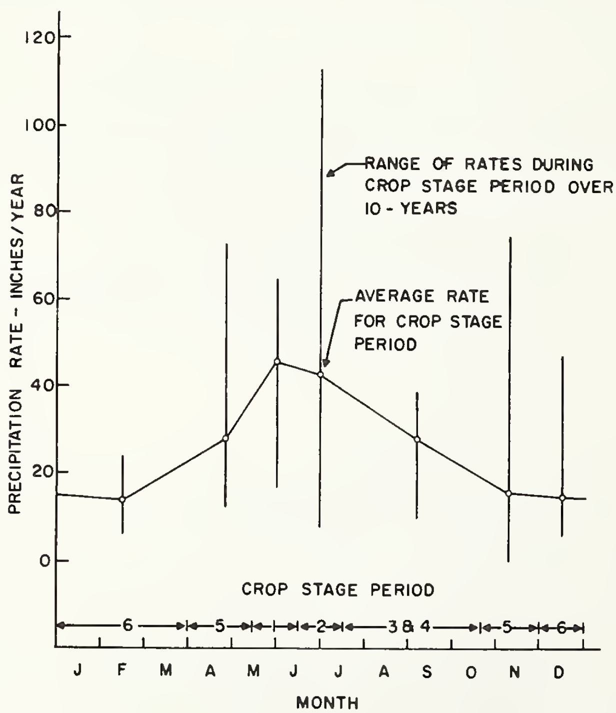

FIGURE 1.—Rates of precipitation during corn crop stage periods expressed in inches per year.

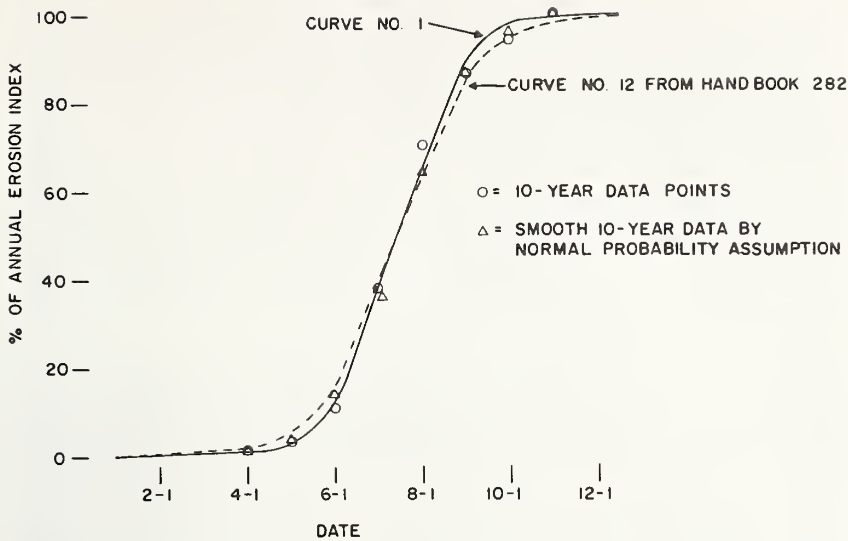

FIGURE 2.—Comparison of erosion-index data for 10 years at Morris, Minn. with curves published in Agriculture Handbook No. 282.

runoff and low temperatures, and early July was the period of high-intensity thunderstorms.

The effect of the treatment on runoff was as expected. Little water from rainfall ran off the hay plots. Except for the cropping period between snowmelt and oat planting, which lost 20 percent of the rainfall, runoff from the rotation, corn-oats-hay, was less than 10 percent. Runoff from the continuous corn plot was higher than from the rotation plots. Eight percent of the annual rainfall was lost from the cultivated fallow plot.

Soil Losses.—The 10-year average soil loss values (table 2) provide a basis for establishing cropping factor (C) values for the Barnes soil areas. As already known, the rotation of corn-oats-hay is a good soil-saving cropping system. Losses from continuous corn on slopes as steep or steeper than the experimental plots will exceed any allowable losses if conservation practices are not used.

Also of interest is the variation of annual soil loss amounts over 10 years (table 2). Annual rainfall for 1962 was the highest during the 10 years; soil loss for the fallow plot amounted to 52 percent of the total and the oat treatment accounted for 91 percent. The soil loss for rotation oats is probably high because 1962 was the second crop year in the experiment and hay had not yet been established in the rotation. However, the data in table 2 illustrate the extreme variability of Minnesota annual soil loss. For 7 years out of 10, continuous corn was grown up-and-down hill on a 6 percent slope without exceeding allowable soil losses (3T/A/Y). But, soil losses were extremely high 2 of the other 3 years, and 1 year alone accounted for more soil loss than the other 9 years combined.

Little erosion was attributed to snowmelt. Although snowmelt runoff amounts were large, runoff rates were low and soil detachment by raindrop action was absent.

Crop Yields.—Generally crop yields followed the level of rainfall with higher yields corresponding to higher rainfall (see appendix D). Continuous corn yields were 66 bushels per acre, rotation corn 72 bushels per acre, oats 87 bushels per acre, and hay 2.7 tons per acre.

Conclusion and Summary

Soil-cover had a pronounced effect on soil losses among crop treatments and seasonal periods. Variation of annual soil losses showed that continuous corn was grown on 6 percent slopes (on the test soil, Barnes) without excessive erosion about 7 out of 10 years. But, erosion in just 1 year out of the 10 exceeded soil loss from the other 9 years combined. Even the sod-based rotation of corn-oats-hay produced excessive soil losses in the 1 year. Those rotation plots, when in hay, effectively reduced erosion to zero.

Data from this 10-year study of soil erosion in the northwestern fringe of the Corn Belt are presented for limited analysis. These data contribute to the set of basic data required for evaluating the parameters of the Universal Soil Loss Equation.

Rainfall amounts over the period averaged 20 inches and snowfall was 4.65 inches-water-equivalent. Annual rainfall ranged from a drouthy 12.02 inches to a season of excess of 29.74 inches. Erosion potential in terms of the EI parameter exceeded the long term value of 100 in 2 out of 10 years.

Literature Cited

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Appendix A: Soils Description

An intensive soil survey of the Barnes-Aastad Soil and Water Conservation Research Association Farm was completed in the summer of 1961. SCS Soil Scientists Ernest Miller, Don DeMartalaere, and Royce Lewis made the soil survey with assistance from ARS personnel.

Stakes were set on a 100-feet grid. Soil profile observations were made at each stake. In places, the profiles were observed at 25 to 50 feet intervals to place the soil boundaries more accurately. Most of the profiles were observed from soil cores taken with a hydraulic probe, especially the lower part of the profile. The thickness, color, texture, and effervescence with hydrochloric acid were recorded at each location. On the basis of these and other characteristics, each profile was placed in the appropriate soil series. Over 100 profiles were observed.

Barnes Soils

The Barnes soils are well-drained Chernozems (Udic Haploborolls) developed in loam textured glacial till and have A, B, and C horizons. The average ratio of the thickness of the A to B horizons is about 1.0.

A horizons: The average thickness of the A horizon (material 10YR2/2 or darker) is 9 inches. Two-thirds of the profiles fall within a range of 6 to 12 inches. A thin transitional horizon with 10YR2/2 colors occurs in 26 percent of the profiles. Thirty-four percent of the profiles have a surface color of 10YR2/1-2/2 or 2/1-3/1. All the rest of the profiles have a surface color of 10YR2/1.

B horizons: The thickness of the bright-colored B horizon averaged 9 inches, with two-thirds of the profiles falling within a range of 6 to 12 inches. The hue of the B horizon is 10YR. Most of the B horizons can be divided into such upper and lower parts as B21 and B22 on the bases of value and chroma.

In the B21 horizon the most common value is 3 with a range of 2 to 4. The most common chroma is 2. About one-fourth of the profiles have chroma of 3, and about the same number have chroma of 2 to 3 or 2.5. Only a few profiles have chroma of 3 to 4 or 3.5.

In the B22 horizon the most common value is 4. Occasionally it has a value of 3, but more frequently the value is 3 to 4 or 3.5. Chromas of 3 and 4 occur with about equal frequencies.

In some of the thinnest profiles the subsoil horizon with the higher values and chromas is lacking. But in others, especially those where the surface soil has been removed by erosion, the subsoil horizon that has the lower values and chromas is lacking. Some of the profiles show thin patchy clay films. In others there is no evidence, by field methods, of clay films.

C horizons: The depth to the C1ca horizon averaged 18 inches. Two-thirds of the profiles fall within a range of 13 to 23 inches.

Nearly all of the C1ca horizons have 2.5Y hues. Only a few have 10YR hues. The values range from 5 to 6 with slightly higher frequencies of 5. The chromas range from 3 to 4, and have about equal frequency distributions.

No appreciable difference occurs between the color of the C1ca and C2 horizons. No 10YR hues were observed in the C2 horizons.

Conceptional model of Barnes loam

Horizon	*Description*
Ap	0-6 inches, black (10YR2/1) loam; weak fine granular and sub-angular blocky structure; friable; many bleached sand grains; abrupt smooth boundary.
A1	6-9 inches, black (10YR2/1) loam; weak to moderate, fine to medium sub-angular blocky structure; friable; many bleached sand grains; clear wavy boundary.
B21	9-13 inches, very dark grayish brown (10YR3/2) loam; weak medium prisms breaking to weak to moderate fine and medium sub-angular blocky structure; friable; clear smooth boundary.
B22	13-18 inches, dark brown to dark yellowish brown (10YR4/3-4/4) loam; weak medium prisms breaking to weak to moderate fine and medium sub-angular blocky structure; friable; abrupt wavy boundary.
C1ca	18-32 inches, light olive brown to olive brown (2.2Y5/4-4/4) loam; structureless; friable; strong effervescence with hydrochloric acid carbonates in form of threads and smears; diffuse smooth boundary.
C2	32-54 inches, light olive brown (2.5Y5/4) loam; few fine olive and common medium faint grayish brown mottles; structureless; friable; strong effervescence with hydrochloric acid.

Appendix B: Crops and Soils Management

All planting and tillage operations were done up-and-down hill. Hybrid corn was drilled in 40-inch rows to a stand of about 16,000 plants per acre. Oats were drilled in 7-inch rows using 2.5 bushels seed per acre. Meadow seeding was 9-pounds per acre of smooth bromegrass mixed with the oats at seeding. Alfalfa was band seeded at the rate of 6-pounds per acre at oat seeding time.

Fertilizer application was made on the basis of soil tests to a level recommended for 100-bushels per acre corn yield.

Tillage: Plowing for corn was done in the fall; plow depth was 6 inches. A two-way moldboard plow was used to alternate soil movement each year. The lower end of the plots next to the permanently installed runoff collector was hand spaded and cultivated. A double-disk and spike-tooth harrow were used in the corn plots just before planting. The corn plots were cultivated 2, 4, and 6 weeks after planting; sweeps alone were used for the first cultivation; disk hillers were added for the second and third cultivation.

The fallow plots were treated similarly to the corn plots except they were cultivated when necessary to prevent prolonged surface crust formation.

The oat plots were prepared for planting with disking as needed.

Insect control: The plots were sprayed as needed for insect control. However, all weed control was obtained by cultivation and hand hoeing as needed.

Planting and seeding: Corn was planted with a 2-row planter. Oats were seeded with a conventional grain drill. Both the planter and seeder were mounted so that planting could be done by backing down the plot and planting up hill.

Appendix C: Precipitation, Runoff, and Soil Loss

Data is given for each year by crop periods. All data are averages of three replications except crop stage 6.

TABLE 4.—*Precipitation during crop periods of corn, hay, and fallow treatments*

	Spring						Fall		Annual totals	
Corn and fallow	5	6	1	2	3	4	5	6	Rain	Snow
Hay	4A	6	4B	4C	4D[1]		5	6		
	Inches									
1962	9.15	1.59	5.37	9.36	5.78	0.08	0	0.53	29.74	2.12
1963	4.04	3.10	4.26	.66	8.42	0	1.12	1.77	18.50	4.87
1964	2.30	3.85	1.59	5.16	9.04	0	.20	.51	18.29	4.36
1965	2.61	5.97	6.61	4.92	10.39	0	.84	1.20	25.37	7.17
1966	1.77	3.27	1.39	3.16	10.10	0	.56	.84	16.98	4.11
1967	2.93	3.68	4.11	2.45	2.56	0	.03	.88	12.08	4.56
1968	4.31	1.89	2.97	1.86	6.25	3.70	.13	4.01	19.22	5.90
1969	4.64	3.86	1.97	2.16	7.27	0	1.00	1.39	17.04	5.25
1970	1.47	3.31	4.77	.95	4.60	0	6.16	1.01	17.95	4.32
1971	1.48	3.11	4.50	4.60	5.73	.25	8.41	.74	24.97	3.85

[1] Rainfall for hay period 4D is total of that for corn period 3 and 4.

Table 5.—*Precipitation during crop periods of oat treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 4A	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches									
1962	1.25	1.59	13.24	9.39	1.85	3.93	0.08	0.53	29.74	2.12
1963	.15	3.10	1.70	5.98	.73	8.82	1.12	1.77	18.50	4.87
1964	2.19	3.85	.15	3.86	3.00	8.89	.20	.51	18.29	4.36
1965	1.16	5.97	4.97	4.09	4.89	9.42	.84	1.20	25.37	7.17
1966	1.28	3.27	1.62	2.60	1.30	9.62	.56	.84	16.98	4.11
1967	2.72	3.68	3.47	2.94	.36	2.56	.03	.88	12.08	4.56
1968	.45	1.89	2.95	2.83	3.06	6.10	3.83	4.01	19.22	5.90
1969	2.86	3.86	3.00	1.92	2.15	6.11	1.00	1.39	17.04	5.25
1970	1.36	3.31	1.77	3.65	.45	4.56	6.16	1.01	17.95	4.32
1971	.10	3.11	1.38	4.61	5.38	4.84	8.66	.74	24.97	3.85

Table 6.—*Runoff during corn crop periods from continuous fallow treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches									
1962	2.29	0.85	1.22	2.57	0.22	0	0	0	6.30	0.85
1963	.01	.03	.04	0	.18	0	0	0	.23	.03
1964	0	.02	0	1.35	1.62	0	0	0	2.97	.02
1965	.15	5.14	.23	.55	.42	0	0	0	1.35	5.14
1966	0	2.97	0	.12	.71	0	0	0	.83	2.97
1967	.55	3.43	.23	.42	0	0	0	0	1.20	3.43
1968	.01	.14	0	.03	.29	.03	0	0	.36	.14
1969	.01	7.24	0	0	.95	0	0	0	.96	7.24
1970	0	6.77	.73	0	.04	0	0	0	.77	6.77
1971	0	6.48	.17	.70	.44	0	.74	0	2.05	6.48

Table 7.—*Runoff during crop periods of the continuous corn treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches									
1962	1.68	0.70	1.09	2.48	0.36	0	0	0	5.61	0.70
1963	0	.01	.11	0	.14	0	0	0	.25	.01
1964	0	.49	0	.96	1.31	0	0	0	2.27	.49
1965	.17	4.39	.46	.50	.12	0	0	0	1.25	4.39
1966	0	.27	0	.02	.62	0	0	0	.64	.27
1967	.23	2.02	.35	.38	0	0	0	0	.96	2.02
1968	.02	0	0	.08	.42	.01	0	0	.53	0
1969	0	6.26	0	0	.30	0	0	0	.30	6.26
1970	0	5.17	.74	0	.01	0	0	0	.75	5.17
1971	0	1.33	.29	.32	.02	0	.07	0	.70	1.33

TABLE 8.—*Runoff during crop periods of the rotation corn treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches									
1962	0.35	0.04	1.06	2.02	0.27	0	0	0	3.70	0.04
1963	0	0	.08	0	.09	0	0	0	.17	0
1964	0	.01	0	.78	1.02	0	0	0	1.80	.01
1965	0	1.50	.27	.30	.07	0	0	0	.64	1.50
1966	0	1.79	0	.01	.25	0	0	0	.26	1.79
1967	.01	1.82	.22	.30	0	0	0	0	.53	1.82
1968	.02	0	0	.04	.29	0	0	0	.35	0
1969	0	2.32	0	0	.26	0	0	0	.26	2.32
1970	0	2.08	.64	0	.01	0	0	0	.65	2.08
1971	0	.18	.24	.23	.04	0	.11	0	.62	.18

TABLE 9.—*Runoff during crop periods of the rotation oat treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 4A	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches									
1962	2.43	1.32	1.52	2.22	0.17	0	0	0	6.34	1.32
1963	0	.01	0	.05	0	.01	0	0	.06	.01
1964	0	.01	0	0	.35	.37	0	0	.72	.01
1965	.14	5.53	.16	.44	.18	.01	.47	0	1.40	5.53
1966	0	.18	0	0	0	.02	0	0	.02	.18
1967	.13	1.72	.01	.23	0	0	0	0	.37	1.72
1968	0	.05	.03	.01	.03	0	0	0	.07	.05
1969	0	8.99	.03	0	0	0	0	0	.03	8.99
1970	0	4.15	0	.37	0	0	0	0	.37	4.15
1971	0	.22	0	.06	.06	0	0	0	.12	.22

TABLE 10.—*Runoff during crop periods of the rotation hay treatment*

Year	Spring 4A	Spring 6	4B	4C	4D	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Inches								
1962	0.04	3.48	0.49	0.61	0.05	0	0	1.19	3.48
1963	0	.79	0	0	.01	0	0	.01	.79
1964	0	3.74	0	.16	.05	0	0	.21	3.74
1965	0	8.55	0	0	.05	0	0	.05	8.55
1966	0	2.94	0	0	0	0	0	0	2.94
1967	.03	3.80	0	0	0	0	0	.03	3.80
1968	0	1.06	0	0	0	0	0	0	1.06
1969	0	18.77	0	0	0	0	0	0	18.77
1970	0	3.80	.01	0	0	0	0	.01	3.80
1971	0	3.08	0	0	0	.07	0	.07	3.08

TABLE 11.—*Soil loss during corn crop periods from the continuous fallow treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Tons per acre									
1962	18.67	0.33	26.37	32.52	2.80	0	0	0	80.36	0.33
1963	.03	0	.24	0	.50	0	0	0	.77	0
1964	0	0	0	20.44	14.46	0	0	0	34.90	0
1965	.10	5.31	.30	2.35	4.42	0	0	0	7.17	5.31
1966	0	.28	0	1.19	2.33	0	0	0	3.52	.28
1967	6.93	.74	.67	1.94	0	0	0	0	9.54	.74
1968	.02	0	0	.11	1.08	.06	0	0	1.27	0
1969	.01	0	0	0	2.40	0	0	0	2.41	0
1970	0	3.55	5.45	0	.11	0	0	0	5.56	3.55
1971	0	.97	.97	5.55	.93	0	.66	0	8.11	.97

TABLE 12.—*Soil loss during crop stage periods from the continuous corn treatment*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Tons per acre									
1962	8.39	0	16.39	18.48	1.23	0	0	0	44.49	0
1963	0	0	.40	0	.30	0	0	0	44.49	0
1964	0	1.32	0	8.02	2.49	0	0	0	10.51	1.32
1965	.01	.90	.50	1.68	.24	0	0	0	2.43	.90
1966	0	0	0	.06	.30	0	0	0	.36	0
1967	1.44	0	.67	1.03	0	0	0	0	3.14	0
1968	.02	0	0	.21	.32	0	0	0	.55	0
1969	0	0	0	0	.29	0	0	0	.29	0
1970	0	.03	5.69	0	.03	0	0	0	5.72	.03
1971	0	.21	1.32	1.36	.03	0	.08	0	2.79	.21

TABLE 13.—*Soil loss during crop stage periods from the rotation corn treatments*

Year	Spring 5	Spring 6	1	2	3	4	Fall 5	Fall 6	Annual totals Rain	Annual totals Snowmelt
	Tons per acre									
1962	0.58	0	9.12	10.79	0.56	0	0	0	21.05	0
1963	0	0	.30	0	.11	0	0	0	.41	0
1964	0	0	0	2.42	1.22	0	0	0	3.64	0
1965	0	0	.29	.67	.11	0	0	0	1.07	0
1966	0	0	0	.07	.12	0	0	0	.19	0
1967	.05	0	.24	.33	0	0	0	0	.62	0
1968	.05	0	0	.09	.20	0	0	0	.34	0
1969	0	0	0	0	.26	0	0	0	.26	0
1970	0	0	4.20	0	.01	0	0	0	4.21	0
1971	0	.04	.91	.74	.02	0	.16	0	1.83	.04

TABLE 14.—*Soil loss during crop stage periods from the rotation oat treatment*

Year	Spring						Fall		Annual totals	
	5	6	1	2	3	4	4A	6	Rain	Snowmelt
	Tons per acre									
1962	[1]11.88	0	3.81	0.75	0	0	0	0	16.44	0
1963	0	0	0	.03	0	0	0	0	.03	0
1964	0	0	0	0	.10	.03	0	0	.13	0
1965	.01	.95	.18	.05	0	0	0	0	.24	.95
1966	0	.01	0	0	0	0	0	0	0	.01
1967	.58	.38	.01	.05	0	0	0	0	.64	.38
1968	0	0	.04	.01	.01	0	0	0	.06	0
1969	0	0	.05	0	0	0	0	0	.05	0
1970	0	0	0	.32	0	0	0	0	.32	0
1971	0	.01	0	.07	0	0	0	0	.07	.01

[1] Adverse weather required oat replanting. The soil loss of 11.88 tons between planting and replanting was assigned to period 5.

Appendix D: Crop Yields

TABLE 15.—*Yields for continuous and rotation corn*

Year	No. 2 Corn yield		Plant population		Stover yield	
	Continuous	Rotation	Continuous	Rotation	Continuous	Rotation
	Bushels per acre		*Plants per acre*		*Tons per acre*	
1962	90	89	18,000	18,000	2.39	2.35
1963	89	100	16,600	17,300	2.65	2.90
1914	54	43	16,700	16,100	2.38	2.43
1965	63	71	15,300	15,200	2.31	2.76
1966	38	40	13,400	13,700	1.64	1.61
1967	61	59	12,800	14,400	2.06	2.15
1968	64	62	15,700	15,500	2.16	2.13
1969	57	76	17,200	16,800	2.23	2.35
1970	65	69	15,900	15,700	2.02	2.05
1971	80	105	16,200	16,300	2.21	2.44
10-yr average	66	72	15,800	15,900	2.20	2.32

Table 16.—*Yields from rotation oat treatment*

Year	Grain yield	Straw yield
	Bushels per acre	*Tons per acre*
1962	55	1.72
1963	83	1.71
1964	68	1.87
1965	138	2.52
1966	19	1.69
1967	149	2.60
1968	102	2.69
1969	83	2.38
1970	74	1.74
1971	98	2.40
10-year average	87	2.13

Table 17.—*Yields from rotation hay treatments*

Year	Cutting First	Cutting Second	Cutting Third	Total
		Tons per acre		
1962	1.44	1.22	0.60	3.26
1963	1.24	.70	.93	2.87
1964	1.78	.91	.99	2.68
1965	1.20	.91	.73	2.84
1966	.69	.61	.77	2.07
1967	1.35	1.19	.32	2.86
1968	.77	.72	.74	2.23
1969	1.26	.75	.48	2.49
1970	1.61	.92	.89	3.42
1971	1.06	.55	.69	2.30
10-yr. average	1.24	.85	.71	2.70

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